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THE RECENT ERUPTIONS OF COLIMA.

THE *Volcán de Colima* with the *Nevado de Colima* together form a magnificent mountain mass at the extremity of a branch of the Sierra Madre, known, at no great distance from the volcano, by the name *Sierra de Tapalpa* (Fig. 1). Colima lies in latitude $19^{\circ} 30' 25''$ N., and longitude $4^{\circ} 37' 55''$ W. from Mexico. Its altitude is 3,960.90^m, while that of the *Nevado* is 4,334.57^m. The two peaks are seven kilometers apart. The volcano is thirty-three kilometers from the city of Colima and twenty-five kilometers from Zapotlan. Both *Volcán* and *Nevado* are in Canton 9 of the state of Jalisco, Mexico.

From Zapotlan the volcano presents the form of an elegant cone with slopes of 45° ; the *Nevado*, seen from there, appears upon the west flank of the cone and a little to the north (Fig. 2). The volcano has long been active, and during the last century made notable eruptions in 1804, 1806, 1808–18, 1869, etc. (Fig. 3).

The above description is condensed from a paper by Padre José Maria Arreola which was printed in the monthly bulletin of the Mexican meteorological observatory in 1896.¹ In this article Father Arreola described the work of observation being conducted by himself at Colima and his colleague Castellanos at Zapotlan. Rarely has any volcano been subjected to such careful scrutiny and record as has Colima by these two devoted observers. Three times daily, from 1893 through a period of seven or eight years, the conditions of the volcano were carefully recorded and sketches made, if there were any signs of activity. Precise terms were employed in description. Vapor was "dense" or "thin;" "dense," when emitted rapidly, as if in eruption, and in volutes; "thin," when issuing slowly, continuously, as if filtered out. For force, degrees from 0 to 10 were recognized, running parallel with the verbal terms—"little,"

¹J. M. ARREOLA, "El Volcán de Colima," *Boletín mensual del Observatorio meteorológico central de México*, 1896, p. 10.

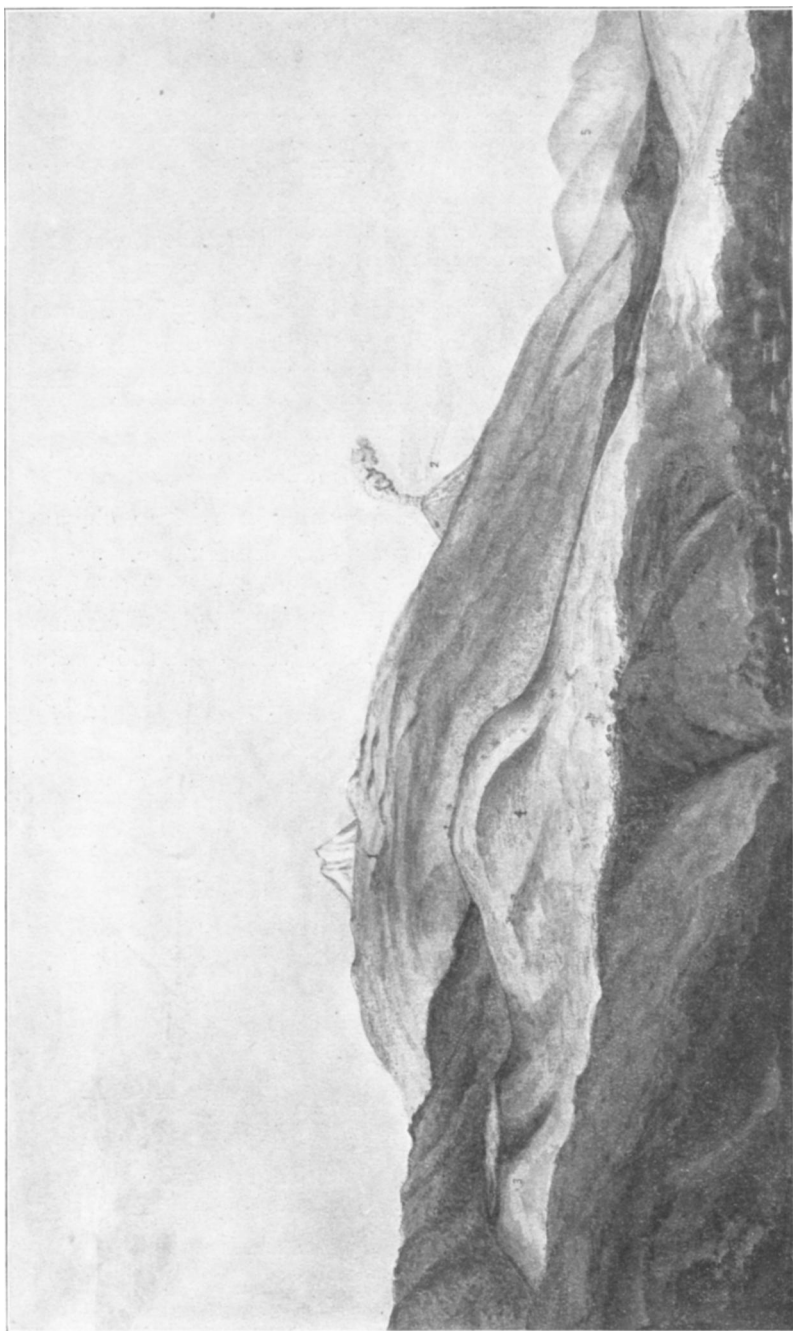


FIG. 1.—View of the volcano Colima from San Gabriel; seen looking southwest. (1) Nevado; (2) Colima; (3) and (4) Los Gallos small, extinct volcanoes; (5) Montitules.

“regular,” “moderate,” “great,” and “maximum.” Some of these records of observation have been published in the various issues of the bulletin already mentioned. It is greatly to be desired that the whole mass of them, together with the tri-daily sketches, might be published in one volume. During February and March of the present year (1903) the volcano has been notably active. Father Arreola, though no longer living within observation distance of the volcano, visited it during this time of

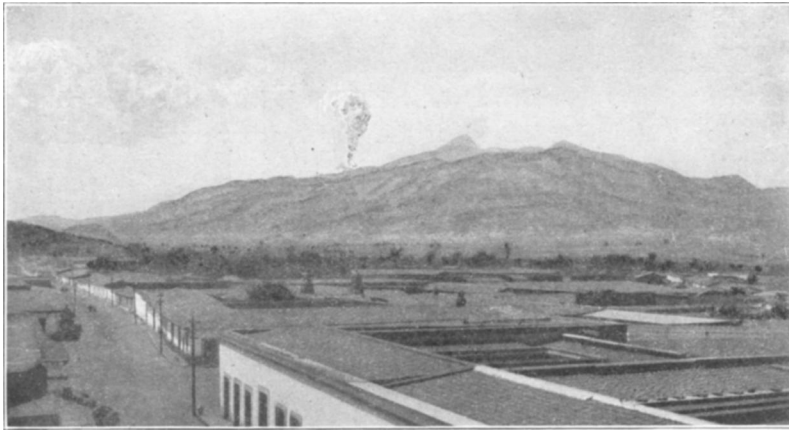


FIG. 2. —Photographic view of Nevado and Colima, taken from the observatory of the Seminary of Zapotlan. The volcano lies to the southwest; the little Apaxtepetl is at the extreme left. The summit of the volcano is visible behind the crest of the Nevado.

eruption and secured the records kept by others. He has printed a pamphlet, in Spanish, presenting the facts.¹ As this pamphlet is practically inaccessible to students, I have translated so much of it as is descriptive, retaining the author's arrangement and headings. Father Arreola has loaned the original photographs and drawings for reproduction.

FREDERICK STARR.

BRIEF NOTICE OF THE OBSERVATIONS OF COLIMA.

Passing over the history of the eruptions, which, for several years past, Colima has given—which is to be found elsewhere

¹ *Las erupciones del volcán Colima en Febrero y Marzo del corriente año.* Guadalajara: Luis G. Gonzales, 1903; 8vo, pp. 26; seven cuts.

—it is my intention to summarize the condition of the volcano during the past eleven years. In a note entitled “Datos de los temblores, erupciones, lluvias y otros fenomenos observados en Zapotlan,” which I sent to the Central Observatory, and which was printed in its *Boletin*, in the year 1894, among other matters, I gave notice of a great eruption in the early days of March, 1892, which produced an abundant fall of dust, carried by a current of air from the southwest. No other notable eruption was observed during that year. In 1893, with the opening of the meteorological observatory of the Seminary of Zapotlan, began systematic and continuous observation of all the manifestations of the volcano, reinforced, from the beginning of 1896, by the similar labors of the observatory of the Seminary of Colima.

Through the whole space of time since, the condition of the volcano and the character of all its manifestations have been noted, day by day. The records of the two stations form an inestimable treasure for science, which before could only deal with isolated data, which were often of uncertain character. By an examination of these records . . . it is seen that Colima, during this period of eleven years, has been in a condition of constant, irregular, and feeble activity.

From a study, presented by Severo Diaz, presbyter, at the Third National Meteorological Congress, in December last, we may summarize this period in the following statement :

From 1893 to 1898 the volcano continuously emitted thin vapors, forming streaks, varying in direction with the wind, attaining a length of from forty to fifty kilometers, and losing themselves on the horizon. In the midst of this constant, but feeble, activity it was not rare to see, from week to week, an eruption—regular or moderate.

From 1898 to 1899 this continuous activity was converted into eruptive emission; during this period about eight little eruptions were often observable in the space of two hours.

Finally, from the end of 1899 to 1902, the continuous activity gave way completely to eruptive emission. During this period little eruptions were repeated at intervals of three or four hours;

during the intervals the volcano remained completely inactive. Through these years there were recorded some thousand little eruptions in each year; these at times produced light showers of fine sand in the vicinity of Zapotlan.

From the beginning of the present year a notable diminution was observed in the eruptions; these no longer followed the periods determined in the previous years; the intervals of



FIG. 3.—Photographic view of Colima from the Hacienda de San Marcos, March 11, 1901. The volcano lies to the west; the cone and the secondary cone being in the center; the Nevado at the right, and Monticules at the left.

inactivity were longer, apparently preludeing the new period of great activity.

RECORD OF THE OBSERVATIONS OF COLIMA DURING THE PERIOD OF GREAT ACTIVITY (1903).

February 15.—At 3 A. M., from the Hacienda de Santa Cruz de Duque, a great eruption was observed, after which fire was seen upon the volcano. . . . At 11 A. M. ashes fell at the same hacienda, probably proceeding from a second eruption. From Zapotlan there was no report, on account of rain. From Colima, at 1 P. M., a great eruption was seen.

February 16.—Insignificant escape of vapor.

February 17.—At 7:45 A. M. and 11:45 A. M., moderate eruptions, borne to the west and the southwest. During the rest of the day insignificant escape of vapor.

February 18.—At 12:45 P. M. an explosion was heard from the volcano, and immediately a maximum eruption burst forth with great force, completely filling the crater and covering the slopes with its products; it continued for more than a half-hour, during which the west wind bore the gaseous and sandy products toward the villages of Tuxpan, Tecalitlan, etc. Another eruption followed. The hot stones and scoriæ, which were poured out in great quantity over all the slopes of the volcano, set fire to trees on various parts of the summit of the mountain. . . . The great quantity of matter thrown out in these eruptions, and in those of the 21st and 24th, was almost wholly material which had been accumulated gradually, above the crater, during its time of slight activity, as may be shown by a comparison of photographs taken before and after the events. Once the crater was disembarrassed, no such abundant outflows were recorded, from which it may be inferred—at least in the present period—that there is no risk of a greater invasion of scoriæ.

February 19.—At 6:15 and at 10 A. M., moderate eruptions. At 12:15 and at 1:30 P. M., little eruptions, all drifted by strong west winds.

February 20.—Inactivity all day.

February 21.—At 9:30 A. M., regular eruption. At 12:15 P. M. a heavy detonation was heard which threw the air into commotion, even shattering the walls of houses. . . . The noise had been heard for some seconds, when a great eruption broke forth, the colossal proportions of which could not be fully appreciated on account of the products being violently swept by the west wind to the east of the volcano. The rain of sand over this region was distinctly visible from Zapotlan. At 3:30 P. M. there was another great eruption. Its products were drifted by the west wind into the state of Guanajuato.

February 22 and 23.—Insignificant issue of vapor, carried by the west wind.

February 24.—At 3:15 P. M., a great eruption, with characters similar to those of the 21st. The products were promptly distributed to the east, sand raining over Tonila; in their descent, however, they were drifted by the lower air-current from the south, so that the sands were carried to Zapotiltic, Zapotlan, Sayula, Guadalajara, etc. The rain of fine sand—commonly called ashes—began at Zapotlan, at 4 P. M., and was so heavy that persons could not be distinguished at a distance of fifty meters. The fall lasted more than two hours, forming a sheet one millimeter in thickness. On this day, by telescopic observation of the volcano, a change in form of the upper part of the crater was noticed. The sands which fell in Tonila were as coarse as common sand, those falling in Zapotiltic were finer, those of Zapotlan and Sayula were like ashes, and so decreasingly with increasing distance. . . . At about 7 P. M. was observed a little overflow of glowing scoriæ. A great eruption was reported for 10 P. M.

February 25.—At 4 A. M. there was a great eruption, preceded by a report.

At dawn the volcano was wrapped in a cloud of its own erupting. During the rest of the day there was a constant emission of thin vapor, which sallied as if filtered through the west side of the crater.

February 26.—Until 3 P. M., enveloped in cumulus clouds; after that hour, inactive. There must have been an eruption during the night, since at dawn the summit of the *Nevado* was covered with sand.

February 27 and 28.—Almost inactive.

March 1.—Completely inactive.

March 2.—At 6:50 P. M., a maximum eruption, less, however, than those of the 18th, 21st, and 24th past; it was so spread by the southwest winds that at 8 P. M. it reached the opposite horizon. After this eruption, grains of porphyritic stone rained down upon the fields situated at twenty kilometers southeast of the volcano. Of these grains I collected in Piaya and in Platanar some of the size of grains of corn. At places nearer the volcano stones fell. From the ranch of Cauzentla, one of the nearest to the volcano, three were found weighing one hundred and thirty-six, thirty-four, and thirteen grams—the two larger being of the same nature as the grains of Piaya and the sands of other localities. The nature of these pebbles, of the grains, and of the sands gives reason to believe that all are derived from the rocks constituting the cone, broken and reduced by heat and the force of projection. The fine dust, commonly called ashes, which exists in great quantity over the flanks of the volcano and which is also distributed by the eruptions, is of pumiceous nature and proceeds from the solid and broken lavas of the interior of the crater.

March 3.—At dawn Mr. Diaz observed with the telescope a new change in the form of the crater. . . . From this alteration it appeared that the crater, which had become almost completely clogged during the period of little activity (Fig. 4), had been thoroughly opened (Fig. 5). Little columns of vapor were seen ascending from the bottom of the crater. During the middle part of the day the volcano was covered with atmospheric clouds. At 5:45 P. M. there was a great eruption, almost maximum; as the air was calm, the vertical cloud could be long observed. The cloud was driven by a high current from the southeast, until, at 9 P. M., it touched the northwest side of the horizon of the valley of Zapotlan.

March 4.—At 6 P. M., a great eruption, driven by the southwest wind, until it promptly disappeared. This eruption produced an overflow of scoriæ on the eastern flanks.

March 5.—At 10:45 A. M., a great, almost maximum, eruption, borne toward the east.

March 6.—Insignificant emissions.

March 7.—At 7:10 A. M., a maximum eruption, preceded by an explosion (Fig. 6). A great eruption at 8:20 and another at 8:45 A. M. All of these drifted to the east. During the rest of the day there were moderate eruptions, some of which lasted several minutes.



FIG. 4.—Cone of the volcano Colima as seen in December, 1902. Drawn with the aid of a telescope at the observatory of the Seminary of Zapotlan. The crater rises behind the crest of the Nevado.

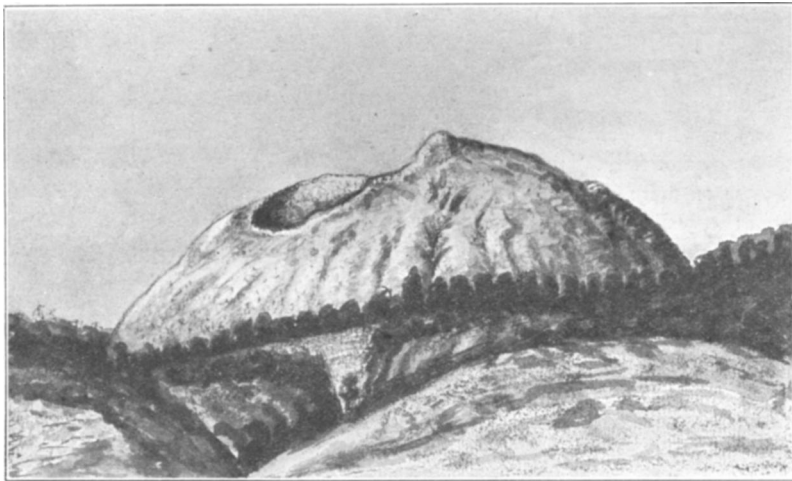


FIG. 5.—Crater of the volcano Colima after the eruption of March 2, 1903.

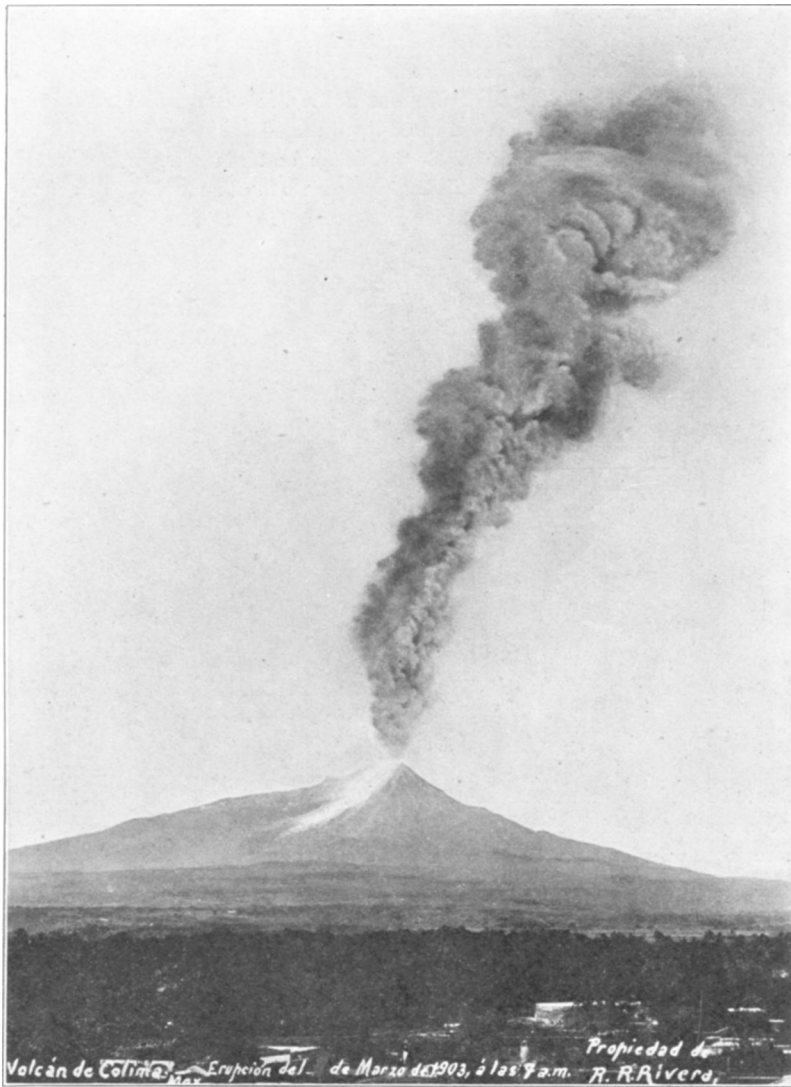


FIG. 6— The volcano Colima in eruption, March 7, 1903, at 7 : 10 A. M., as seen from Colima, the volcano lying to the north. (R. R. Rivera.)

March 8.—Almost inactive.

March 9.—At dawn completely inactive. During the day there were seven little eruptions—at 9:18 and 11 A. M., and 12:24, 1:20, 1:40, 2:20, and 2:47 P. M. During the intervals there was complete inactivity. At 7:45 P. M., preceded by a heavy rumbling, there was an eruption, during which there was an abundance of fire and flashes, through the mass. There was a moon, and its white rays, reflected upon the edges, gave the cloud clean and immaculate outlines with which the black and red tones at the center sharply contrasted. The spectacle was indescribably beautiful. The cloud

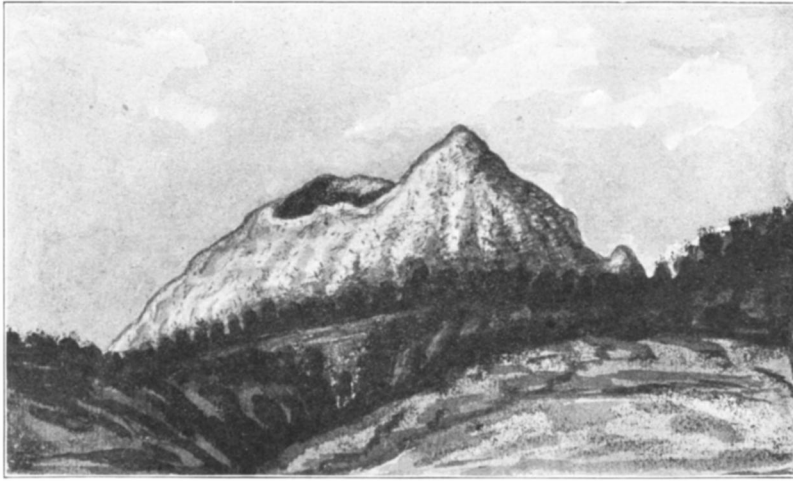


FIG. 7.—Crater of Colima after the eruption of March 10, 1903.

directed itself to the northeast, over the city of Zapotlan; the vapor mass had already passed the zenith of that city when, with an almost clear sky, there began a rain of coarse sand, the fall of which made a sound like the pattering of an ordinary rain. Of this sand two hundred and fifty grams were collected to an area of a square meter, on an average. In some parts of the city pieces of stone, up to the size of a grain of barley, were collected. This fall began at 8 P. M., and lasted about an hour.

March 10.—Little clouds were observed at 6:15, 7:05, 7:27, 9:34, and 10:47 A. M. At 1 P. M., a maximum eruption, borne by the southwest wind toward the valley of Zapotlan, where some coarse sand fell—and, later, very fine sand like that of February 24. The quantity collected this time averaged about one hundred and seventy-five grams to the square meter, and the fall lasted some twenty minutes. At this time the crater suffered an alteration of form on the west border (Fig. 7); presenting thereafter on all sides an irregular border, with projecting points, in the form of a crown.

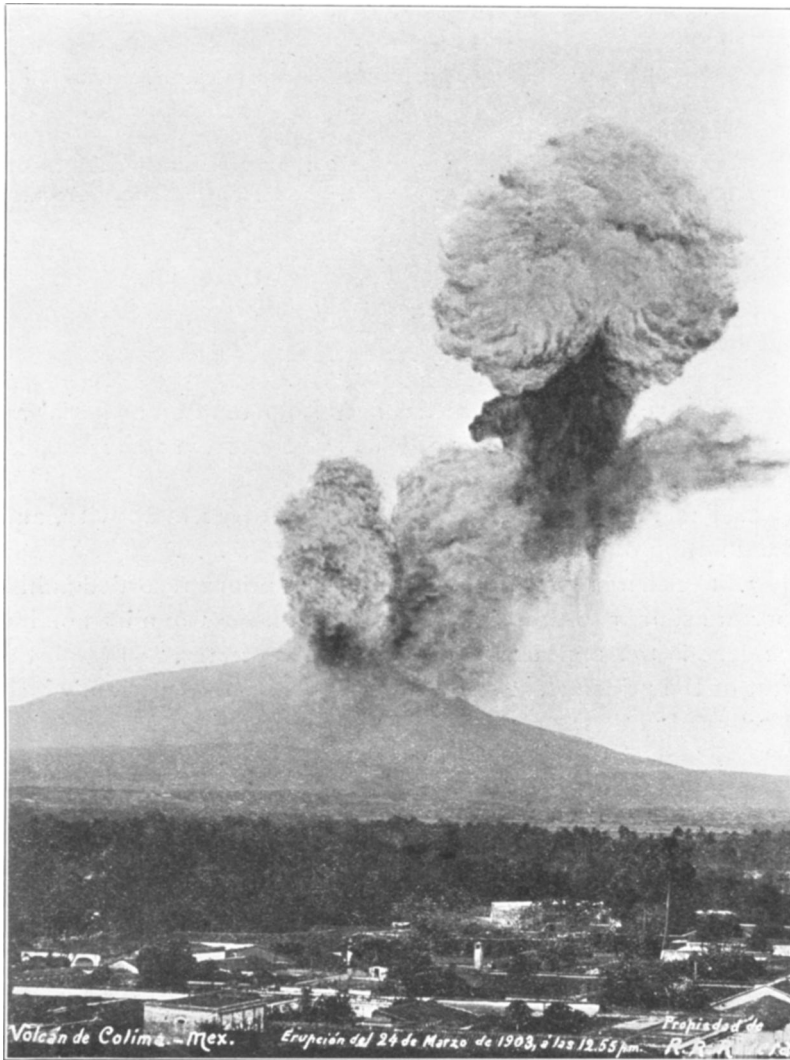


FIG. 8.—Colima in eruption on March 24, 1903, at 12:55 P. M., as seen from Colima, the volcano lying to the north. (R. R. Rivera.)

March 11, 12, and 13.—Almost inactive.

March 14.—At 1 A. M., a great eruption, with fire in the cloud and overflow of glowing scoriæ on the flanks. It produced a rain of fine sand to the east, in Tonila, and to the southwest in the Hacienda de San Antonio, estimated, at the latter place, at ten grams to the square meter. Inactive the rest of the day.

March 15-23.—Almost inactive.

March 24.—At 1:55 P. M., a maximum eruption, in six impulses, during the period of thirty-five minutes (Fig. 8). At the beginning frequent rumblings were heard, during some five or six minutes. The cloud directed itself east-northeast; and produced a rain of coarse sand in Tuxpan, Tecalitlan, etc.

March 25-31.—Almost inactive.

CONCLUSIONS.

1. The volcano of Colima has been from time immemorial an active volcano, the eruptions of which gain force, in some periods, until they assume a violent character.

2. The intervals between the periods of great activity, and the duration of these periods, are irregular

3. The characters of all the violent eruptions recorded in history are similar to those of the present time. The only notable incident is the appearance of a secondary crater, to the northwest of the principal, at the beginning of the 1869 period, which functioned until 1872.

4. From the examination of the flanks of the volcano and from recent superficial observations, it is inferred that the volcano has never thrown out lavas. All that lies upon the constituent rock mass of the cone, and all lately ejected, are fragmentary material—pebbles and sands of various grades of fineness, some with marks of having been exposed to heat and to the emanations from the crater. It appears, then, that they do not proceed from the internal reservoir.

5. The reason that this volcano has never belched forth lava is that its impulsive force has never been sufficient to overcome the height—3,960 meters above sea level. The lava rises to a level lower than this in the crater, and only the hot scoriæ, floating upon its surface, overflow.

6. The heavier products erupted fall upon the higher slopes

of the volcano, no more than four or five kilometers from the crater, where they do no harm. The pebbles and the sands, which have rained upon the low and populated districts, have caused no damage to persons or to cultivated fields.

7. The existence of *solfataras* in this volcano has not been proved; sulphur probably forms no part of its emanations.

8. The scoriæ and sands which issue from the crater are stopped in their course by the *barrancas* (gorges) which exist about half-way up the cone; these *barrancas*, existing on all sides and at various altitudes, serve as receptacles and protectors. If the higher ones are filled up, the lower ones receive the discharge. As the material is uncompacted, it is easily removed and the *barrancas* are cleared by the later rains. . . .

9. As there are no signs that the eruptive power of Colima is augmenting, the inhabitants of the neighboring country may live tranquil. . . .

10. The most violent eruptions have agitated the air sufficiently to produce loud explosions, but have not caused earthquakes.

JOSÉ MARIA ARREOLA.